Effects of Differing Farm Policies on Farm Structure and Dynamics

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Government agricultural programs have a variety of goals, among them is preserving the family farm (U.S. Department of Agriculture 2003, pp. 18–20). While no single program is dedicated to maintaining a certain type of farm structure, program features are sometimes designed so as not to disadvantage family farms. For example, dollar limits may be placed on payments that a single person can receive. But our understanding of how government policies have affected the structure of agriculture, or how future policies could be designed to promote specific outcomes remains limited. Leathers has shown that the impact of agricultural programs on the structure of agriculture cannot be predicted by theory alone.

A major factor contributing to farm consolidation is economies of scale. Economies of scale allow more agricultural product to be produced at lower per unit costs, but lower per unit costs may also result from increases in productivity, that is, changes in the underlying technology. It is important to account for this continuous and significant technical change in trying to isolate the impact of government programs on U.S. agriculture. Huffman and Evenson, for example, examined how farm structural change and government policies affect productivity. They assumed that farm structure affected productivity, but that farm productivity did *not* affect farm structure. Public R&D, they found, affects farm structure, while agricultural policies had a small impact on structure. In contrast to Huffman and Evenson, Ahearn, Yee, and Huffman modeled farm structure and productivity as a two-way relationship, and found that government investments had positive and significant impacts on productivity. They also found that government commodity payments had a negative impact on the off-farm labor supply of farm households and a positive impact on farm size. Key and Roberts considered the effect of payments on farm size and survival of payment recipients, ignoring the role of productivity, and found payments had a positive, but small, effect on farm size.

This article builds on previous empirical studies that examined government policies, productivity, and farm structure. We ask not only how payments have affected productivity, off-farm work, and farm size, but also whether they have influenced farm exits from agriculture altogether (for 1982–97). We examine how policies have affected all farms, not just those that participate in programs. Our empirical analysis does not include the period following the passage of recent farm legislation, but we expect that these policy changes will have no significantly different impacts on structure than did prior legislation.[1]

Farm Structure

Farm structure is most simply characterized by the size of farms and their farm and household characteristics. It is also useful to consider the underlying dynamics of entry and exit. There are approximately 2.1 million farms in the United States.[2] Since1978, the total number of farms has changed relatively little, declining by 0.25% per year from 1978 to 2002. This slow rate of decline was unexpected. For example, in a landmark 1986 study, the Office of Technology Assessment (OTA) estimated that by the year 2000 there would be only 1.25 million farms, compared to the more than 2 million that actually existed.

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[1] Our expectation is based in large part on the empirical analysis of the post 1996 period. See Organisation for Economic Co-operation and Development for a recent review of the empirical literature, which finds little or no difference in acreage and production as a result of the 1996 legislation.

[2] The farm definition since 1975 is any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold.

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Table 1. Actual and OTA Projected Distribution of U.S. Farms by Sales Class in 1982 Dollars

	Actual 1982		Actual 1997		OTA Projected 2000	
Sales Class (1982 Dollars)	No. Farms	% Farms	No. Farms	% Farms	No. Farms	% Farms
<$20,000	1,355,344	61	1,142,286	60	637,597	51
$20,000–$99,999	581,576	26	396,317	21	362,555	29
$100,000–$299,999	180,689	8	153,398	8	75,011	6
$300,000–$499,999	93,891	4	139,434	7	125,019	10
≥$500,000	27,800	1	80,424	4	50,008	4
Total	2,239,300	100	1,911,859	100	1,250,190	100

Sources: Office of Technology Assessment and calculations based on U.S. Department of Agriculture 2001.

Whether farm size is measured in acres or gross sales, the size distribution of farms is highly skewed, and has become more skewed over the past several decades. The OTA report cited above also forecasted the size distribution of farms in 2000 and again got it wrong (table 1). The OTA projection underestimated the staying power of farms in all sales classes, but especially in the small sales class, incorrectly predicting the loss of about 500,000 small farms.

Off-farm income helps account for the staying power of these small farms. More than three quarters of today's farms have gross farm sales less than $50,000 and, on average, lose money farming. In spite of their low or even negative farm incomes, their off-farm income is above the U.S. average income for all households. For all farm households combined, only about 5% of total farm household income is from farm sources. Farm households with gross farm sales of $50,000–$500,000, while heterogeneous in many ways, are similar in the number and types of commodities produced and their participation in government programs. Farms with sales over $500,000 have a different profile in a number of respects. The largest farms are more likely to use contracts and to produce high-value crops and livestock, other than dairy. Given the focus of direct payment programs on cash grains and cotton, the largest farms are less likely than midsized farms to receive payments, although large farms that receive payments average a higher payment than smaller farms.

The aggregate amount of U.S. farmland has been relatively stable during the twentieth century, and so the change in the number of farms is closely correlated with the change in the average number of acres in a farm, which has generally been increasing until recently. Since 1978, the total number of farms has remained at about 2 million. The number of large farms (>1,000 acres) and smallest farms (<50 acres) have increased, while the number of midsized farms has declined. There were about 160,000 large farms in 1978, compared with 176,000 in 2002. While 16,000 more farms may seem insignificant among over 2 million farms total, the concentration of production is more telling. In 1978, 7% of all farms produced half of all farm output. By 2002, 1.6% of U.S. farms (approximately 34,000) accounted for half of all output.

The slow rate of decline in the number of farms masks the high exit and entry rates (Ahearn, Yee, and Korb). From 1978 to 1997, exit rates varied from 9% to 10% per year and entry rates from 8% to 11% (table 2), compared with the 0.25% decline in the total number of farms. The size distributions of farms both exiting and entering were generally smaller than continuing farms. Small farms are more likely to enter and exit than are midsized and large farms (table 2). Between 1992 and 1997, more small farms entered than exited the sector, contributing to greater concentration of production on fewer farms. The farms that continue in business also change size over time. Some farms expand, but other farms contract. For example, during 1992–97, only about 30% of the continuing farms did *not* expand or reduce their acres operated. The fact that so many continuing farms change size is likely reflective of the tie between farm size and the lifecycle of the farm household.

Government Intervention in Agriculture

For most of the twentieth century, the U.S. government has intervened in the agricultural sector, via regulations, subsidies, and research investments, often in five-year cycles related to changes in legislation. Other support for agriculture comes from programs with multiple goals, such as infrastructure investment, tax policy, conservation programs, and energy

Table 2. Annual Farm Exit and Entry Rates by Farm Size

Acre class	1978–1982	1982–1987	1987–1992	1992–1997
		Exit rates		
1–49	13.6	14.3	13.5	12.7
50–99	10.7	10.7	10.2	9.5
100–179	9.8	9.6	9.3	8.8
180–259	8.6	8.8	8.4	8.0
260–499	7.9	8.2	7.7	7.6
500–999	7.4	7.9	7.0	7.0
1,000–1,999	7.4	7.4	6.4	6.6
2,000 plus	7.6	7.3	6.4	7.0
All farms	10.0	10.4	9.7	9.3
		Entry rates		
1–49	17.5	13.0	12.5	13.8
50–99	10.9	8.5	8.5	10.6
100–179	9.5	7.6	7.5	9.0
180–259	8.5	7.1	6.8	7.8
260–499	7.9	6.8	6.3	7.0
500–999	7.6	6.7	5.7	6.4
1,000–1,999	7.6	6.6	5.4	6.0
2,000 plus	7.8	7.2	5.8	6.4
All farms	11.1	8.8	8.3	9.6

Note: Values are expressed in percentage.

programs. (Some argue that domestic nutrition programs also support agriculture by increasing demand for farm products.)

One way to decipher all the ways in which agriculture is supported is with methods adopted by the World Trade Organization (WTO). An "aggregate measure of support (AMS)" excludes programs that are not subject to official WTO notifications, such as conservation programs. The level of support varies across time and across commodities. Part of the reason that some commodities may account for a large share is because of the aggregate quantity produced. In 2001, the total AMS for the United States was estimated at $21.5 billion (U.S. Department of Agriculture 2005). The commodity with the largest share of that total was dairy (21%), followed by soybeans (17%), cotton (13%), corn (6%), and sugar (5%). The distribution of income support payments is relatively easy to track as a result of their transparency. Total income supports vary considerably across years because the programs change (e.g., on an ad hoc emergency basis) or because many of the programs are tied to changing market conditions.

Direct support payments also vary considerably across farms. In 2003, approximately 40% of U.S. farms received government payments. The most common payment, received by 22% of farms, was direct payments. Other major federal programs provided the following payments: countercyclical payments (to 9% of farm households), milk income loss payments (to 3% of farm households), disaster and emergency assistance payments (to 11% of farm households), and Conservation Reserve Program payments (to 13% of farm households).

Although the majority of farms do not receive payments, large farms are more likely to receive payments than are small farms, so most of the value of production (60% in 2003) is produced on farms that receive payments. Mid-sized farms ($50,000–$500,000 annual sales) are actually more likely to participate in government payment programs than are the very smallest or very large farms. Direct payments have historically been targeted toward cash grain and cotton farms, based on volume, so larger farms who participate in programs have higher average payments. For example, participating farms that produce under $50,000 in product averaged under $4,000 in payments in 2003, while participating farms with $500,000 or more in product, averaged over $64,000.

A Theoretical Framework of Farm Structure and Government Policies

A variety of conceptual models consider the structural change process in agriculture (see Harrington and Reinsel for a review). Early intuitive explanations for understanding the relationship between innovation, surpluses, and reallocation of agricultural outputs and inputs are the "treadmill" and the "farmer cannibalism" models described by Cochrane. Cochrane was greatly influenced by Schumpeter's *Theory of Economic Development*, particularly the dynamic nature of Schumpeter's process of "creative destruction" (Levins, p. 28). An emerging literature in empirical industrial organization that focuses on nonfarm firms also builds on Schumpeter's work (e.g., Hopenhayn). What the emerging models have in common is that they assume firms that have heterogeneous productive efficiency are subject to various sources of uncertainty, and focus on the consequences of high entry costs. These assumptions allow the models to explain the divergent paths of entry, exit, and reallocation that characterize the observed firm-level data. According to Hopenhayn, following a random productivity shock, φ, the distribution of future productivity is represented by

$$(1) \qquad F(\varphi_{t+1} \mid \varphi_t).$$

Each firm chooses to exit or remain in the industry. If they choose to remain, they pay a fixed cost C_f. Potential entrants into the industry can enter by paying an entry cost, C_e. The level of C_e will affect the flows of entering and exiting firms. A high C_e will raise the level of profits needed to make entry profitable and lower the minimum productivity needed for continuing firms to stay in business and avoid exiting. High entry costs may result in lower producer entrants and can play the role of helping to sustain low productivity firms, by lowering competition from potential new firms. Farming is often considered to be an industry with high entry costs because of the high cost of farmland, which may have implications for the productivity of farms. However, unlike the entry costs of most industries, farmland is an investment that has generally appreciated steadily over time.

The emerging models of nonfarm firms do not adequately capture the role played by the dual residence–business objectives of the majority of farm households. The unique relationship that a farm household has with the farm business means that micro decisions of farm businesses must be modeled along with micro decisions of farm households in a household production model. The household production model is especially useful for characterizing individual micro decisions. The conceptual model combines the decisions of agricultural households relating to production, consumption, and labor supply into a theoretically consistent model (e.g., Huffman). The individual is assumed to allocate time to farm work, off-farm work, and leisure in such a fashion that the optimal allocation is achieved when the marginal values of time devoted to the activities are equal. The farm operator household is assumed to have the optimization problem:

$$(2) \qquad \text{maximize}\, U = U(C_h, T_h; H, Z)$$

$$\text{with} \quad \frac{\partial U}{\partial \Omega} > 0, \quad \frac{\partial^2 U}{\partial \Omega^2} < 0, \quad \Omega = C_h, T_h$$

where U is joint household utility, C_h is goods and services consumed by the household, T_h is leisure (or home time) of household members, H is the human capital of household members, and Z is other household and local area characteristics. The standard constraints are the time allocations (to farm, off-farm, and leisure) and the budget constraint that include farm profits based on the farm production function, income from off-farm work, and unearned income, including government payments. One of the possible solutions for the farm household is to provide no labor to the farm business, that is, to exit agriculture entirely. Farm households will continue in farming as long as the marginal utility per dollar earned from additional farm work is greater than the marginal utility per dollar earned from additional off-farm work. Otherwise, standard economic theory would predict that farm households will exit farming. This model can be extended to explain other dimensions of farm structure. For example, increased off-farm work may be associated with smaller farm size, as more time spent working off-farm means less time available for working on the farm. Human capital and other household characteristics may have an impact on farm level productivity, as well as the allocation of time between farm and off-farm work. Individual farm production and household choices lead to aggregate indicators of farm structure, such as the overall size distribution of farms or farm exit rates in a state.

The Empirical Model

We estimate the model by three-stage least squares, incorporating cross-equation correlation of disturbances. We employ a panel data set constructed for forty-eight states and four time periods—1982, 1987, 1992, and 1996. We employ the following five-equation model:

$$(3)\quad \text{TFP} = \alpha_1\text{Small} + \alpha_2\text{Large} + \alpha_3\text{Off} + \alpha_4\text{Exit} + \alpha_5 X_1 + u_1$$

$$(4)\quad \text{Small} = \beta_1\text{TFP} + \beta_2\text{Off} + \beta_3\text{Exit} + \beta_4 X_2 + u_2$$

$$(5)\quad \text{Large} = \gamma_1\text{TFP} + \gamma_2\text{Off} + \gamma_3\text{Exit} + \gamma_4 X_3 + u_3$$

$$(6)\quad \text{Off} = \delta_1\text{TFP} + \delta_2\text{Small} + \delta_3\text{Large} + \delta_4\text{Exit} + \delta_5 X_4 + u_4$$

$$(7)\quad \text{Exit} = \varepsilon_1\text{TFP} + \varepsilon_2\text{Small} + \varepsilon_3\text{Large} + \varepsilon_4\text{Off} + \varepsilon_5 X_5 + u_5.$$

The five equations are for productivity (TFP), the share of farms less than 50 acres (Small), the share of farms more than 1,000 acres (Large), the odds that farm operators work off-farm at least 200 days per year (Off), and the odds that a farm exits the sector (Exit). The variables are provided in table 3, and data sources are fully described in Ahearn, Yee, and Korb. Which variables are included in each equation are clear from the structural results of table 4.

The structural coefficients indicate the relationships among the endogenous variables. The impact of an exogenous variable on an endogenous variable is, however, given by the reduced form coefficient. The reduced form coefficients take into account both the direct and the indirect effects of an exogenous variable on each endogenous variable. We can write our system of structural equations in period t in matrix form as

$$(8)\quad \mathrm{B}y_t + \Gamma x_t = u_t.$$

The system of reduced form equations can be written as

$$(9)\quad y_t = \Pi x_t + v_t.$$

The relation between the structural coefficients and the reduced form coefficients can be derived by solving equation (8) for y_t

$$(10)\quad y_t = -\mathrm{B}^{-1}\Gamma x_t + \mathrm{B}^{-1}u_t.$$

Comparing this with the reduced form equation (9), we can derive the reduced form coefficients from the structural coefficients as

Table 3. Variable Definitions

Variable	Definition
TFP	Level of total factor productivity (relative to Alabama in 1987)
Small	Share of farms in state less than fifty acres
Large	Share of farms in state more than 1,000 acres
Off	Proportion of farm operators who worked 200 or more days off farm
Exit	Annualized exit rate between previous and current censuses
Ownrd	Own research stock
Spillin	Spill-in research stock
Ext	Extension stock per farm
Hiway	Highway stock
Privrd	Private research
Spec	Specialization computed as a Herfindahl index, based on 10 commodity categories
Contract	Proportion of farms with production contracts
Compay	Real commodity payments per farm
Conpay	Real conservation payments per farm
Setaside	Diverted acres per farm
Insureacre	Share of acres enrolled in crop insurance
Valueacre	Real land and building value per acre
College	Proportion of farm operators with a four-year college education or more
Young	Proportion of farm operators under thirty-five years old
Old	Proportion of farm operators sixty-five years old and older
Kw	Farm machinery price-hired farm labor wage ratio (lagged one year)
Mw	Manufacturing wage-hired farm labor wage ratio (lagged one year)
Areanm	Share of acres in state classified as nonmetro
Popden	Population density in nonmetro areas
Drought	Drought dummy
Flood	Flood dummy
Dairy	Dummy variable equal to 1 if dairy is greater than 20% of total cash receipts

Table 4. Structural Coefficients for Full Model and Reduced Form Coefficients for Selected Exogenous Variables, 1982, 1987, 1992, and 1996 ($n = 192$)

Variables	ℓTFP	ℓSmall	ℓLarge	ℓ[Off/(1 − Off)]	ℓ[Exit/(1 − Exit)]
Endogenous variables					
ℓTFP		1.443*	−2.589*	−0.427*	0.131
ℓSmall	0.214*			0.164	0.280*
ℓLarge	−0.169*			−0.145	−0.106*
ℓ[Off/(1 − Off)]	−0.458*	1.750*	−0.413		−0.061
ℓ[Exit/(1 − Exit)]	0.678	−3.015*	3.121*	0.489	
Exogenous variables					
ℓownrd	0.101*	−0.014	0.137		
ℓspillin	−0.045	0.022	0.085		
ℓext	−0.039	0.409*	−0.175		
ℓhiway	−0.048			0.019	
ℓspec	0.019	−0.026	0.299*	−0.144*	−0.010
ℓcontract	0.044*	−0.036	0.180*	0.037*	0.015
ℓcompay	0.033*	0.060	0.181*	−0.036	0.019
ℓconpay	0.091*	−0.146*	0.292*	0.020	−0.041*
setaside	−0.001				
insureacre	0.0004*	−0.0005	0.002*	0.0001	0.0001
ℓvalueacre					−0.157*
ℓareanm		−0.063*	0.042		
ℓpopden				−0.027	
ℓprivrd	0.0001	0.00004	0.00030		
ℓkw	−0.683*	0.415	−2.845*		
ℓmw				0.115	0.028
ℓcollege				0.253*	0.176*
ℓyoung		0.086	−0.13	0.190*	0.058
ℓold		−0.552	−0.59	0.485*	−0.252*
drought	0.013				
flood	0.001				
dairy	−0.051			−0.069	
Intercept	6.563*	−10.415*	25.257*	−1.735*	−1.332*
R^2	0.642	0.553	0.865	0.781	0.453
Derived reduced form coefficients for selected variables					
ℓownrd	0.186	0.048	−0.161		
ℓspillin	−0.121	−0.027	0.250		
ℓext	0.084	0.347	−0.081		
ℓcompay	0.047	−0.028	0.119	−0.073	0.009
ℓconpay	0.090	0.009	−0.005	−0.028	−0.024
insureacre	0.0002	−0.0004	0.001	−0.0002	−0.0001

Notes: "ℓ" in front of a variable denotes taking the log. Seven regional dummies were included, but not reported in table.
*significant at the 5% level.

$$\Pi = -\mathrm{B}^{-1}\Gamma. \tag{11}$$

Results

Table 4 reports the structural coefficients for the full model and the reduced form results for those exogenous variables of greatest interest in this article. A large share of the estimated coefficients is significantly different from zero and the share of the variation explained is acceptable. Given the log–log specifications of the structural equations, the coefficients can be interpreted as elasticities. Hence, the magnitude of the coefficient provides an indication of the importance of the variable. In general, the results underscore the importance of modeling the relationships simultaneously.

We begin by highlighting some of the significant relationships among the endogenous variables as evident in the structural coefficients. First, an increase in off-farm work had a negative and significant effect on TFP. This would be consistent with the hypothesis that as farm operators allocate time to off-farm work and generate household income, it comes at the cost of higher productivity in farming.[3] Secondly, an increase in off-farm work increased the share of small farms. More time spent working off-farm means less time available for working on the farm. Thirdly, an increase in the exit rate decreased the share of small farms and increased the share of large farms. Fourthly, a decrease in TFP increased off-farm work; possibly low-TFP operators may be more likely to work off-farm full-time out of necessity. Finally, an increase in the share of small farms increased the exit rate, while an increase in the share of large farms decreased the exit rate, consistent with the results in the farm size equations.

We now focus on the reduced form coefficients at the bottom of table 4 for the policy relevant exogenous variables: public R&D and extension, commodity and conservation payments, and federal crop insurance. A state's own public research and extension were both found to increase TFP. This is consistent with past studies that have stressed the importance of public research and extension in TFP (e.g., Huffman and Evenson). Surprisingly, a state's own public R&D and extension had positive effects on the share of farms that were small and negative effects on the share of farms that were large, probably reflective of the same factors which accounted for the negative effect of farm size on TFP.

While commodity payments had a slight positive effect on TFP, they reduced the share of small farms, increased the share of large farms, and increased farm exits. This is consistent with the view that farmers use the commodity payments to expand their farm size (Collins). A midsized farm may use the payments to buy the land of a smaller neighbor and move up to the large farm size category. Commodity payments increased the exit rate of all farms. While recipient farms are likely to have their chance of surviving and growing increased as a result of government payments, not all farms receive payments. Hence, it is likely that the farms which received payments had the opportunity to expand their farm size by buying out the farmland of nonrecipients, or perhaps recipients who are less productive. A major source of land for farm expansions, especially in specific regions, is exiting farms. In fact, supporting statistics from the Census longitudinal file show that farms that exited were less likely to receive government payments. The effects of conservation payments on TFP were similar to those of commodity payments, but conservation payments had different impacts on some indicators of farm structure. Most of the conservation payments are for participation in the Conservation Reserve Program (CRP), which generally requires that the land be set-aside in various types of conserving uses. A disproportionate share of CRP participants is older, presumably because of the less stringent labor requirements of the CRP relative to agricultural production. Conservation payments increased the share of small farms and decreased the share of large farms, while decreasing exits from agriculture. Payments, whether commodity or conservation, had the effect of decreasing off-farm work participation. Federal crop insurance had a small impact on all of the endogenous variables, and the signs of *insureacre* in the equations confirmed the expected relationships. For example, *insureacre* had a negative effect on the probability of working off the farm, since off-farm work is another form of risk management against low farm incomes.

To gain additional insights on the impacts of government policies, we use the reduced form coefficients to perform some counter-factual simulations following Huffman and Evenson. Figure 1 shows the combined effects of the changes in the policy variables over the period relative to their 1982 level. The proportional difference between the actual and simulated values (for no policy change) indicates that the impact of the public policies studied has been to increase TFP. Public policies also acted to increase the share of large farms on net, although

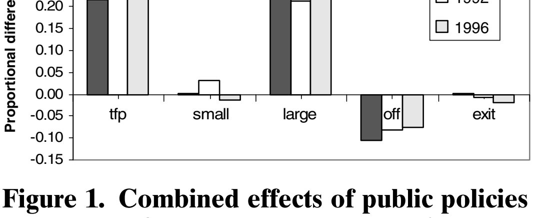

Figure 1. Combined effects of public policies on TFP and farm structure, actual policy levels in a given year relative to 1982 policy levels

[3] An increase in the share of small farms increases TFP, while an increase in the share of large farms decreases TFP. While this result may seem surprising, recall that there are many ways in which to measure farm size and our farm size measures in this model are acres-based. Yee and Ahearn estimated a farm size equation using five different farm size measures: acres operated per farm, real land and building value per farm, real cash receipts per farm, real cash receipts plus government payments per farm, and an imputed measure of the real capital service flow per farm. The acres size measure was the only one negatively related to TFP. Huffman and Evenson also found that farm size reduced crop TFP.

there were differences in the direction of some individual policies which is obvious from the reduced form coefficients of table 4. The combined effects of the public policies on the share of small farms and the exit rate are minimal during the period, although individual policies had differing impacts in terms of direction as well as magnitude. In contrast, if public policies had been held at their 1982 levels rather than their actual levels over the 1982–96 period, participation in off-farm work would have been more than what actually occurred for individual policies in addition to the combined effects featured in figure 1.

Conclusions

This article models the relationships between productivity, government farm programs, and structural change to estimate the net effects of government farm programs on farm structure. We find that commodity payments reduced the share of small farms, increased the share of large farms, and increased farm exits during 1982–96. This is consistent with the traditional view that farmers use commodity payments to expand their farms. Most government interventions that we considered had a positive effect on productivity, but the intervention that had by far the greatest positive impact was investment in public R&D.

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